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OPTIMIZATION OF TIEPOINT EXTRACTION FOR RAPID UAV IMAGE MOSAICKING

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Abstract: The use of UAVs (Unmanned Aerial Vehicles) is increasing in various fields with the rapid development of technology. Along with this increase, UAV image mosaicking became essential to many remote sensing application areas such as time series monitoring. One of the biggest challenges of the mosaicking is the significant time consumption of the process. In particular, tiepoint extraction is the most time-consuming part of the whole UAV image mosaic process. It includes feature keypoint extraction, feature matching, and outlier removal algorithms. This paper focuses on optimization of tiepoint extraction time for fast UAV image mosaicking.

Image downsampling reduces the image size proportional to the square of the scale factor. Consequently, it reduces the calculation process and operating time. On the other hand, excessive downsampling causes data loss and tiepoints with poor quality. The adjustment of feature keypoint quantity shows an analogous pattern to the above. Feature keypoint quantity refers to the maximum number of points to be extracted from each image. We extract feature keypoints for the entire images within the dataset and feed them to feature matching process. Feature extraction operation is reduced in the case of smaller feature keypoints quantity. It also affects the feature matching process afterward. Thus, reducing feature keypoints is effective for reducing overall operation time. Contrarily, an excessively low number of keypoints leads to tiepoints with poor quality or feature matching failure. In this respect, we analyzed proper image downsampling rates and feature keypoint quantity that reduces time to a minimum but maintains the quality of mosaic images.

For experiments, we used four datasets. All datasets were taken from agricultural areas in Korea consisting of from 130 to 220 images. Dataset 1 to 3(Chogye, Anbandegi, Myosan) images were taken by eBee (fixed wing) and Dataset 4(Gimje) images were taken by DJI Phantom 4 (rotary wing). We used the SURF (Speeded-Up Robust Features) algorithm to extract feature points and the linear interpolation for image downsampling. To evaluate the performance, we used the total number of extracted feature points, match points, the number of bundle adjustment successes, processing times, and mosaic images. The number of extracted features and matched points shows the amount of calculation in quantity, and the bundle adjustment success shows the quality of tiepoints.

Table 1 shows that low-quality of tiepoints were obtained with tiepoint extracted from the original images due to image blurring. However, increasing the downsampling rates up to 1/2 shows improved quality in tiepoints and mosaic images. When it exceeded 1/3 rates of downsampling, it showed declines in mosaic image qualities. Thus, we determined the optimal downsampling rates at

1/2 and experimented further with 8 different keypoint quantities. In the case of feature keypoint quantity, the quality of mosaic was maintained up to 50% of the maximum number (65535) applied to the original image. We reduced tiepoint processing time with image downsampling rate of 1/2 by 18% in dataset 1, 6% in dataset 2, 15% in dataset 3, and 6% in dataset 4. Similarly, we reduced tiepoint processing time with keypoints reduced by 50% by 10% in dataset 1, 18% in dataset 2, 11% in dataset 3, and 23% in dataset 4 as compared to maximum keypoints. In conclusion, by adjusting the number of feature keypoints and downsampling images by half, we reduced tiepoint extraction time by an average of 26% while maintaining mosaic quality.

		1.Chogye Region (175 images)				**2.Anbandegi Region (218 images)**			
		Feature Points	Matched Points	Bundle Adjustment	Processing Time (s)	Feature Points	Matched Points	Bundle Adjustment	Processing Time (s)
Down sampling Rates	1	11,272,020	161,275	21	246	14,286,630	675,716	25	314
	1/2	**7,608,424**	**438,691**	**170**	**200**	**10,800,588**	**1,395,063**	**156**	**293**
	1/3	3,788,657	204,365	170	168	10,284,416	611,472	84	217
	1/4	1,980,938	126,791	68	157	2,952,146	370,569	85	193
	1/5	1,292,022	71,277	60	152	2,034,745	201,146	63	184
Keypoint Reduce Rates	1	7,608,424	438,691	170	200	10,800,588	1,395,063	156	293
	7/8	7,597,479	437,666	170	202	10,746,256	1,390,920	155	300
	6/8	7,430,483	417,895	170	198	10,284,416	1,329,213	155	287
	5/8	6,785,676	368,378	167	195	8,905,496	1,137,890	146	257
	4/8	**5,616,683**	**306,333**	**170**	**180**	**7,143,206**	**935,654**	**147**	**240**
	3/8	4,227,072	229,434	170	178	5,357,568	659,165	84	226
	2/8	2,818,048	142,696	67	65	3,571,712	426,679	70	209
	1/8	1,409,024	43,430	8	157	1,785,856	184,891	9	192
		3.Myosan Region (139 images)				**4.Gimje Region (175 images)**			
		Feature Points	Matched Points	Bundle Adjustment	Processing Time (s)	Feature Points	Matched Points	Bundle Adjustment	Processing Time (s)
Down sampling Rates	1	9,109,365	211,865	20	200	11,468,450	794,396	160	291
	1/2	**6,446,874**	**284,242**	**116**	**170**	**10,410,588**	**1,166,341**	**160**	**271**
	1/3	3,256,569	140,349	109	138	7,497,416	527,779	160	214
	1/4	1,836,005	88,803	98	125	2,728,680	306,634	160	181
	1/5	1,239,119	52,023	37	101	1,922,318	162,670	159	172
Keypoint Reduce Rates	1	6,446,874	284,242	116	170	10,410,588	1,166,341	160	271
	7/8	6,436,590	284,191	116	168	9,550,428	1,010,850	160	256
	6/8	6,274,856	280,663	116	166	8,449,025	836,768	160	236
	5/8	5,590,929	246,817	113	158	7,138,118	645,038	160	221
	4/8	**4,546,316**	**211,893**	**112**	**150**	**5,729,465**	**457,429**	**159**	**208**
	3/8	3,416,064	152,056	107	144	4,300,800	296,075	139	198
	2/8	2,277,376	94,774	99	139	2,867,200	179,723	77	189
	1/8	1,138,688	21,931	9	130	1,433,600	64,954	5	5

Table 1. Tiepoint Extraction Results with 4 Datasets

Keyword: UAV image; Feature extraction; Feature matching; Mosaicking; Tiepoint;

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